Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust
Greenfield Environmental Trust Group, Inc., Member
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September 23, 2021

By FedEX and E-mail—charlene.fitch@dnr.mo.gov

Ms. Charlene Fitch, P.E.—Chief, Engineering Section
Missouri Department of Natural Resources
Waste Management Program
1730 E. Elm Street
Jefferson City, MO 65102-0176

Subject: **Northwest Stormwater Basin Sampling Field Implementation Work Plan**
Greene County Highway Department
2065 N. Clifton Ave., Greene County Highway Department

Dear Ms. Fitch:

Pursuant to Section 3.2.6 of the Multistate Environmental Response Trust Agreement, Greenfield Environmental Multistate Trust, LLC, Trustee of the Multistate Environmental Response Trust (the Multistate Trust), hereby "seeks the prior approval of the Lead Agency . . . to perform Environmental Actions and any work plans to be undertaken by the Multistate Trust under the oversight of the Lead Agency . . . ." Accordingly, the Multistate Trust hereby submits the *Northwest Stormwater Basin Sampling Field Implementation Work Plan* (Work Plan) for the Greene County Highway Department (GCHD) property (Property) located immediately adjacent to and east of the Greenfield Environmental Multistate Trust LLC—Springfield Facility, also known as the former Tronox/Kerr-McGee Facility located at 2800 West High Street in Springfield, Missouri (Facility) with Missouri Hazardous Waste Management Facility Part I Permit Number MOD007129406.

The purpose of this Work Plan is to document the proposed sampling locations, field sampling procedures, and analytical methods to be used evaluate the depth and areal extent of Facility-related dense nonaqueous phase liquids (DNAPL as creosote) and contaminants of concern (COC) that are potentially in soil beneath the Property's northwestern stormwater basin. This information will be used (1) to identify specific health and safety considerations, if and when, Greene County and GCHD decide to modify the northwestern stormwater basin and (2) to develop of a soil management plan for Facility-related DNAPL as creosote- and COC-impacted soils, if any. The investigation will follow the field sampling procedures and analytical methods documented in the Missouri Department of Natural Resources (MoDNR)-approved *Final Greene County Highway Department Site Investigation Work Plan*[1].

Tim Davis, Environmental Compliance Manager for Greene County, has reviewed and accepted the Work Plan. Greene County has indicated to the Multistate Trust that they plan to contract with an engineer to prepare the stormwater basin modification design by the end of the calendar year. To facilitate meeting that deadline, the Multistate Trust is requesting (if possible) a two-week expedited review by the MoDNR and to the extent possible, approval (or conditional approval) of the Work Plan by October 15. With approval by October 15, the Multistate Trust's third-party contractor, Environmental Works Inc. (EWI) can start the investigation in mid- to late-October. This allows the Multistate Trust to provide preliminary investigation results to Greene County, GCHD and the

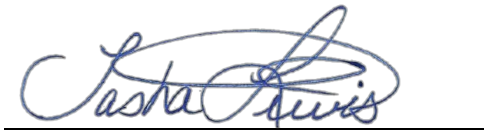
[1] Jacobs Engineering Group Inc. (Jacobs). 2019. Final Greene County Highway Department Site Investigation Work Plan. July 26.

MoDNR by mid-November. A technical memorandum summarizing the results will be submitted to Greene County, GCHD and the MoDNR within four weeks of the receipt of the validated analytical data.

If you have any questions regarding the Work Plan, please contact me at (602) 312-6993 or tl@g-etg.com or Barbara Garcia at (417) 380-3370 or bgarcia@environmentalworks.com, a representative of EWI.

Sincerely,

Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust
By: Greenfield Environmental Trust Group, Inc., Member



Tasha Lewis
Portfolio Manager and Project Manager

Enclosures: Northwest Stormwater Basin Sampling Field Implementation Work Plan

cc: Cynthia Brooks—Multistate Trust
Keith Brodock—Integral Consulting Inc.
Barbara Garcia—Environmental Works Inc.
Lauri Gorton—Multistate Trust
Jillian Hunt—MoDNR
Craig Kaufman—Multistate Trust
Nathan Kraus—MoDNR
Rich Nussbaum—MoDNR
Abby Sawyer—MoDNR

Greene County Highway Department Northwest Stormwater Basin Sampling Field Implementation Work Plan

Prepared For:	**Greenfield Environmental Multistate Trust, LLC Trustee of the Multistate Environmental Response Trust**
Copy To:	**Project File, Greene County, Greene County Highway Department, and Missouri Department of Natural Resources**
Prepared By:	**Environmental Works, Inc.**
Date:	**9/23/2021**
Re:	**Northwest Stormwater Basin Sampling Field Implementation Work Plan Greene County Highway Department 2065 N. Clifton Ave., Greene County Highway Department**

The purpose of this Sampling Field Implementation Work Plan (Work Plan) is to document the proposed sampling locations, field sampling procedures, and analytical methods to be used evaluate the depth and areal extent of dense nonaqueous phase liquids (DNAPL as creosote) and contaminants of concern (COCs) associated with the Greenfield Environmental Multistate Trust LLC – Springfield Facility, also known as the Former Tronox/Kerr-McGee Facility located at 2800 West High Street in Springfield, Missouri (Facility or Site)[1] with Missouri Hazardous Waste Management Facility Part I Permit Number MOD007129406 (Permit), potentially in soil within the subsurface of the northwestern stormwater basin located on the Greene County Highway Department (GCHD) property. This information will be used to identify specific health and safety considerations, if and when, Greene County and GCHD decide to modify the northwestern stormwater basin. This information will also support the development of a soil management plan for Facility-related creosote- and COC-impacted soils, if any. The investigation will follow the field sampling procedures and analytical methods approved by the Missouri Department of Natural Resources (MoDNR) in the Final Greene County Highway Department Site Investigation Work Plan (GCHD Work Plan, Jacobs 2019). For ease of locating, the relevant approved SOPs are attached (Attachment 1).

Background

The *Assessment of Greene County Highway Department's Northeast and Northwest Stormwater Basins (Off-Facility Assessment)*, dated June 21, 2021, was prepared in accordance with the Utility Caution Protocol (UCP, Jacobs 2021)[2] that was developed in 2018 and revised in 2021 (pending finalization) following notification that Greene County is considering modifying the stormwater basins located on the GCHD property at 2065 North Clifton Avenue, Springfield, Missouri (see Figure 1, embedded below). The assessment concluded there is potential to encounter impacted soil or groundwater within the northwest stormwater basin on the GCHD property, but not the northeastern stormwater basin, and to evaluate the depth and areal extent of creosote and other Facility-related COCs, if any. Greene County indicated that, if the northwest basin is modified, the anticipated depth of construction is 3-4 ft below

[1] The Site is referred to as the Former Tronox Facility, Former Tronox/Kerr-McGee Facility, Former Kerr-McGee Facility, Former Tronox/Kerr-McGee Wood Treatment Facility, and/or the Kerr-McGee Chemical Corporation Forest Products Division, Springfield, Missouri Facility.

[2] The UCP identifies High Profile List Areas wherein there is a potential to encounter Facility-related COCs (i.e., constituents of creosote). Within these designated areas, utility workers or others performing subsurface work (for example, soil excavation to repair existing utilities or construction of new utilities) could potentially encounter Facility-related COCs in soil, soil vapor or groundwater. The UCP provides information and guidelines for utility workers and others conducting subsurface work within the High Profile List Areas to reduce the potential for exposure to contaminated soil and groundwater.

land surface [bls][3], which is within a horizon where creosote impact was observed in on-Facility boring logs. No observations of creosote-impacted soil were present in the corresponding horizons in GC-01 on GCHD property, approximately 30 ft east of the stormwater basin.

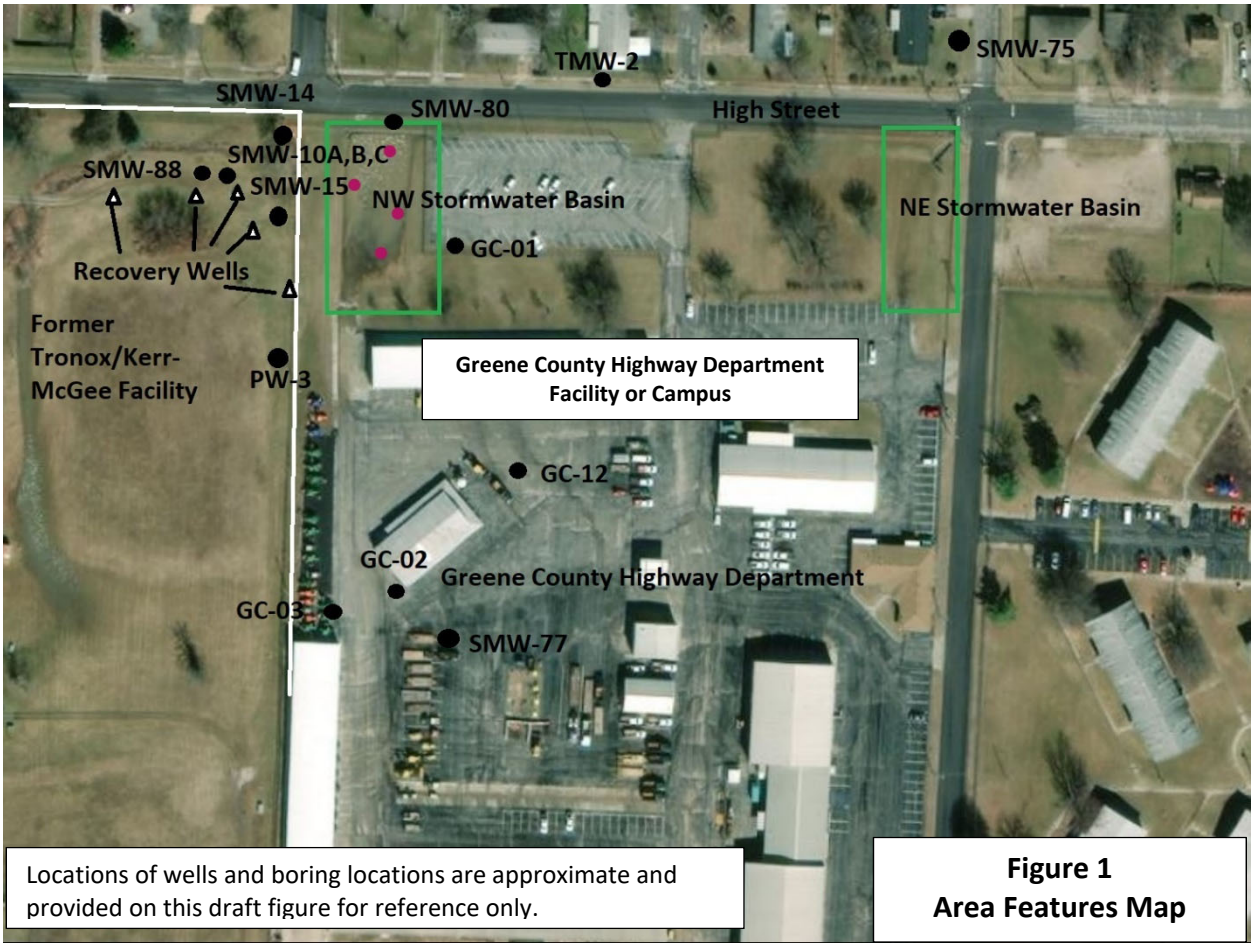


Figure 1
Area Features Map

Scope

Subsurface soil from four locations within the northwest stormwater basin will be evaluated to achieve the following Data Quality Objectives (see also, Table 1):

- Assess the potential for encountering impacted soil (i.e., Facility-related COCs, as defined further below in this plan) within the planned construction area/depth.
- Evaluate the dominant hydrocarbons present in soil (i.e., evaluate if the contamination is Facility-related).

[3] Subsurface data will be collected to 10 ft bls or to bedrock in case Greene County's plans change.

Continuous soil cores will be collected from ground surface to 10 ft bls or to bedrock at each of the four locations shown on Figure 2.. Cores will be visually inspected to identify the presence of impacted material (staining, sheens) or free-phase creosote (oil globules), and field-screened with a photoionization detector (PID).

Figure 2
Boring Location Map

One soil sample will be collected from each location for analysis of the Facility-related COCs. Facility-related COCs include volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) as outlined in the Permit (MoDNR 2020) and listed in Table 2. Soil samples will be analyzed for VOCs by EPA Method SW 8260C and SVOCs by EPA Method SW 8270D and 8270D SIM. The analyses will be performed by Eurofins Lancaster Laboratories with a request for a five-day turn-around for laboratory analysis. As with the GCHD Work Plan, soil samples will also be analyzed for total petroleum hydrocarbons, gasoline-range organics (GRO) and diesel-range organics (DRO), by EPA Method 8015C.

Again, like the GCHD Work Plan, chemical fingerprinting will be conducted on up to four soil samples to identify the dominant hydrocarbons present in the sample. These samples will be collected from sample locations with highest potential for impact (based on visual observations, olfactory detections or PID readings). Soil samples will be submitted for chemical fingerprinting to Alpha Analytical (Mansfield, MA)

and will be analyzed by EPA Method 8015, EPA Method 8270 modified, and EPA Method 8260 modified[4]. Newfields Companies, LLC will provide the fingerprinting evaluation.

Utility clearance will be conducted by contacting Missouri One-Call and by EWI clearing the drilling locations using ground penetrating radar. EWI will request that Greene County or Greene County Highway Department provide updated utilities plans in the area and confirm that there are no utilities with the stormwater basin.

Following the collection of soil cores, the boreholes will be left open until the end of the day to allow for the groundwater level to equilibrate. Prior to abandoning the soil borings with bentonite chips (hydrated in lifts, if needed), a water level indicator will be used to determine the depth of the equilibrated water table. A handheld GPS unit will be used to collect the location and elevation information for each soil boring location so that the drilling locations can be accurately placed on a map of the area. Investigation derived waste (IDW), which will be minimal, will be containerized and disposed of with IDW from the recent GCHD Phase I Site Investigation field work.

Data Evaluation

The information from the investigation will be used to identify the depth and lateral extent of Facility-related impact, if any, in the basin. The laboratory results will be tabulated and compared to the EPA Regional Screening Levels (RSLs) for Industrial Soil and, for reference purposes for use in a future construction health and safety plan, the Missouri Risk Based Corrective Action (MRBCA) risk-based target levels (RBTLs) protective of the Construction Worker exposure pathway (ingestion, inhalation and dermal contact). Table 2 provides a summary of the Facility-related COCs and associated EPA RSLs and MRBCA RBTLs.

The fingerprinting evaluation will utilize the raw concentrations, spectra, and associated quality control results from the laboratory report(s). Results will be compared to laboratory reference samples for examples of hydrocarbon signatures representing the potential petroleum and tar products in the study area for comparison purposes.

Lines of evidence will be used to evaluate whether impacts are Facility-related. These lines of evidence and may include a spatial evaluation of observed conditions and concentration trends, identification of chemicals that are not Facility-related, or calculation of chemical concentration ratios.

A technical memorandum summarizing the data collected and associated findings will be submitted to the Greene County, GCHD, and MoDNR within four weeks of the receipt of the validated analytical data.

[4] The lighter petroleum fraction (i.e., gasoline range) fingerprint analysis will be conducted using a C3-C12 Quantitative Petroleum Characterization (EPA 8260 Modified) or equivalent method. The heavier petroleum fraction (i.e., diesel and motor oil range) fingerprinting analysis will be conducted using the following methods: 1) C8-C40 Full Scan Semi-Quantitative Characterization (Modified ASTM D5739) and 2) Parent and Alkylated PAHs (Modified EPA 8270).

References

Jacobs Engineering Group Inc. (Jacobs). 2019. *Final Greene County Highway Department Site Investigation Work Plan.* July 26.

Jacobs Engineering Group Inc. (Jacobs). 2021. *Utility Caution Protocol for City Utilities and City of Springfield Infrastructure Near the Greenfield Environmental Multistate Trust – Springfield Facility, also known as the Former Tronox/Kerr-McGee Facility, Missouri Hazardous Waste Management Facility Part I Permit Number MOD007129406*. (pending)

Missouri Department of Natural Resources (MoDNR). 2006. *Missouri Risk-Based Corrective Action Technical Guidance*. April.

Missouri Department of Natural Resources (MoDNR). 2020. *Missouri Hazardous Waste Management Facility Part I Permit, Permit Number: MOD007129406*. January 30.

Table 1. Data Quality Objectives

Greene County Highway Department Northwest Stormwater Basin Sampling Field Implementation Work Plan

Issue Statement #	Issue Statement	Data Collection Objective	Investigation Approach Summary Scope Overview	Decision Factors/Criteria
1	The anticipated depth of construction in the northwest stormwater basin (3-4 ft below land surface [bls]) on the Greene County Highway Department (GCHD) property is within a horizon where creosote impact was observed in on-Facility[1] boring logs. No observations of creosote-impacted soil were present in the corresponding horizons in GC-01 on GCHD property, approximately 30 ft east of the stormwater basin.	Evaluate subsurface soil data at the NW stormwater basin on GCHD property to achieve the following objectives below:	Use Geoprobe drill rig / direct push technology (DPT) to collect continuous soil cores to the depth of 10 ft bls or to bedrock at four locations within the northwest basin floor to conduct the following (below):	
		1) Assess the potential for encountering impacted soil (i.e., Facility-related contaminants of concern [COCs]) within the planned construction area/depth.	1) Visually inspect cores to identify the presence of impacted material (staining, sheens) or free-phase creosote (oil globules), and field-screen cores with a photoionization detector (PID).	The depth and areal extent of impact from field screening will be used to approximate the extent of Facility-related impact in the soil.
			2) Collect one soil sample per boring for analysis of Facility-related COCs. Soil samples will be analyzed for volatile organic compounds (VOCs) by EPA Method SW 8260C, semivolatilve organic compounds (SVOCs) by EPA Method SW 8270D and 8270D SIM, and total petroleum hydrocargons (gasoline-range organics [GRO] and diesel-range organics [DRO]) by EPA Method 8015C.	Results will compared to the U.S. Environmental Protection Agency (EPA) Regional Screening Levels (RSLs) for Industrial Soil. For reference purposes only, the results will be compared to Missouri Risk Based Corrective Action (MRBCA) risk-based target levels (RBTLs) protective of the Construction Worker exposure pathway (ingestion, inhalation and dermal contact).
		2) Evaluate the dominant hydrocarbons present in soil (i.e., evaluate if the contamination is Facility-related).	3) Collect up to four samples for fingerprinting analysis at soil sample locations with highest potential for impact (based on visual observations, olfactory detections or PID readings). Soil samples will be analyzed by EPA Method 8015, EPA Method 8270 modified and EPA Method 8260 modified.	Laboratory reports will contain raw concentrations, spectra and associated quality control results to support forensic interpretation. Results will be compared to laboratory reference samples for examples of hydrocarbon signatures representing the potential petroleum and tar products in the study area for comparison purposes.

Table 2. Screening Levels

Greene County Highway Department Northwest Stormwater Basin Sampling Field Implementation Work Plan

Category Parameter[a]		Screening Levels [b]	
		EPA RSLs - Industrial soil IELCR = 1x10-6, HI=1	MRBCA Construction Worker (Ing., Inhalation, Dermal Contact); Soil Type 2
		mg/kg	mg/kg
Volatile Organic Compounds (VOCs)			
Benzene	71-43-2	5.1	1,820
Toluene	108-88-3	47,000	138,000
Ethylbenzene	100-41-4	25	58,100
Xylenes	1330-20-7	2,500	7,210
Semivolatile Organic Compounds (SVOCs)			
Acenaphthene	83-32-9	45,000	25,700
Acenaphthylene	208-96-8	--	53,700
Anthracene	120-12-7	230,000	135,000
Benzo(a)anthracene	56-55-3	21	1190
Benzo(a)pyrene	50-32-8	2.1	119
Benzo(b)fluoranthene	205-99-2	21	1140
Benzo(k)fluoranthene	207-08-9	210	11,900
2-Chlorophenol	95-57-8	5,800	1160
Carbazole	86-74-8	--	40,200
Chrysene	218-01-9	2,100	65,700
Dibenz(a,h)anthracene	53-70-3	2.1	119
Dibenzofuran	132-64-9	1,200	1,340
2,4-Dimethylphenol	105-67-9	16,000	12,100
2,4-Dinitrophenol	51-28-5	1,600	641
Fluoranthene	206-44-0	30,000	43,800
Fluorene	86-73-7	30,000	27,500
Indeno(1,2,3-cd)pyrene	193-39-5	21	724
2-Methylnaphthalene	91-57-6	3,000	1,530
Naphthalene	91-20-3	8.6	215
Phenanthrene	85-01-8	--	35,200
Phenol	108-95-2	250,000	30,900
Pyrene	129-00-0	23,000	33,700

Notes

-- indicates that U.S. Environmental Protection Agency (EPA) has not published a Regional Screening Level (RSL) or Missouri Department of Natural Resources (MoDNR) has not established a risk-based target level for this parameter.

[a] Parameter list from Groundwater Monitoring Constituent list in Table 1- Groundwater Protection Standards in Missouri Hazardous Waste Mananagement Facility Part I Permit (MoDNR 2020).

[b]Screening Levels:
EPA RSLs - May 2020. (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables)
Missouri Risk Based Corrective Action (MRBCA) Departmental Guidance (2006)

Attachment 1

SOPs

Skills Required:

1) 40-hour HAZWOPER training (if drilling on hazardous waste sites)
2) On-site training with experienced person desirable
3) Understanding of, and ability to, make decisions regarding site-specific objectives
4) Knowledge of corporate Safety requirements and health and safety plan
5) Training in soils characterization and sampling (if duties involve sampling)

1. OBJECTIVE / APPLICABILITY

The Objective of this Standard Operating Procedure (SOP) is to provide procedures for planning and observing direct push and hollow-stem auger drilling with considerations for sample collection.

This SOP serves as a reference tool to facilitate consistency among Environmental Works, Inc. (EWI) personnel. These operating procedures may be varied as required, depending upon site conditions, equipment limitations or limitations imposed by the project or client. In all instances, the ultimate procedures employed should be documented and associated with the final report.

2. SCOPE AND PERSONNEL APPLICATION

During any drilling operation, the purpose and ultimate reason for drilling need to be kept in mind. Oversight of drilling for sampling is normally performed by technical personnel (commonly EWI scientists and associate scientists). Any personnel performing these functions should be trained in proper planning and field techniques. The person performing the function is responsible for ensuring that all equipment and materials necessary for drilling are on-hand for the job. If there is any question regarding the purpose of the drilling, the person should confer with the project manager prior to mobilization to the work site.

3. EQUIPMENT

Equipment and materials needed for oversight of drilling operations to include sampling may include but is not limited to the following (this list excludes items specifically used for sample collection; see Sample Collection SOP for those items):

a. A work plan outlining project drilling objectives and locations
b. Field notebook or field documentation sheets
c. Small tape measure
d. Paper towels
e. Nitrile or appropriate disposable gloves
f. PID and calibration gas for VOC sites (including diesel and gasoline sites)
g. Camera (digital best)
h. Fine-tipped Sharpie
i. Trash bags
j. PPE appropriate for the site and COCs; must include hardhat, safety glasses with side shields, ear protection, and steel-toed boots (lace up for BNSF sites)

k. Soil boring logs, Air Monitoring Logs
l. Project Sampling Plan, Quality Assurance Project Plan
m. Site Safety and Health Plan, Tailgate Safety Form

4. PROCEDURES

4.1. General Planning and Procedures PRIOR to Mobilizing to the Field

1) Plan out number of bores, depths, samples needed and sample collection desired, well completion types (screened or open bore bedrock, above or below ground completion) and intervals, size and depths of borings and wells needed, materials needed for well construction, etc. prior to contacting drilling subcontractor for bids.
2) Research, or verify with drilling contractor, the State regulations and requirements for borehole abandonments, annular spaces for well casings and screens, filter pack requirements for monitoring wells, and registrations or reporting requirements
3) If collecting soil samples, plan the type of sample desired and specify to driller for bid: 2-foot split spoons of varying diameters (2"-3" depending on auger size), Shelby tubes, and 5-foot continuous samplers of varying diameter (1.25"-4")
4) If installing wells, plan large enough casing diameters to accommodate purpose of the well or bore (i.e., is a pump going to be installed?)
5) If installing wells, in general use PVC for metals sampling or non-corrosive environments. In corrosive environments (includes high concentrations of chlorinated solvents), use stainless steel casing and screen.
6) If installing PVC wells, use Schedule 40 for depths shallower than 100 feet, and Schedule 80 for depths exceeding 100 feet.
7) Arrange for utility clearances both above and below ground well in advance of the drilling. Even if the client performs the utility clearance, EWI personnel must obtain written verification – and preferably on-site inspection – of utility clearance prior to commencing drilling. Remember that WE are responsible for OUR subcontractor!
8) Arrange for needed equipment, sampling containers, and special items well prior to job startup (i.e., PID monitoring, plastic for berms, drums for cuttings or waste water, or other special tanks or contingency items such as absorbents and floor-dry for spill cleanup).
9) Plan out decontamination procedures and decon areas with driller and client prior to job startup. Who is responsible for materials must be clearly understood.
10) Plan out waste handling, sampling, and disposal responsibilities prior to job startup.
11) Ensure a current Site Safety and Health Plan (SSHP) is available; some drillers require a copy for their records.
12) Prepare SSHP Tailgate Safety Meeting form with pertinent data before the field event.

4.2. General Procedures in the Field and during Drilling Operations.

1) Use Daily Field Logs, Boring Logs, and Air Monitoring Logs to record all pertinent information and activities as the job progresses (example logs are in the Attachments). Examples of what to record:
   - Documentation that Utility Clearance was performed.
   - Documentation that initial SSHP was reviewed and daily Tailgate Safety briefings were performed.
   - Names of drillers, type and condition of drill rig (no leaks!) and serial/State registration number.
   - Other personnel working on the task with you.
   - Key events, start and end times, footages reached, unusual PID readings or observations
   - Any problems arising – causes, details of discussions and decisions with client or regulatory agencies.
2) Measure lengths, and inside and outside diameters of drilling rods, hollow stem augers, bits, samplers, well casing and screens – anything that will go in the hole – and record in field notes using pictures as needed. Sometimes drillers need to change the size of bits or augers – record changes in bit sizes and depths where changes occur on the boring log.
3) Set up "hot zone" Exclusion Zone and Contaminant Reduction Zone perimeters appropriate for the project work and per the SSHP prior to starting drilling. This is advisable even if contaminants are not present to minimize pedestrian encounters. If contaminants are present, appropriate PPE and decon stations must be set up prior to drilling.
4) Set up a plastic-covered plywood stand (use sawhorses or back of pickup truck) if sampling will be conducted. Use a fresh or well-cleaned piece of plastic for each borehole.
5) Distances and directions from known locations (building corners, etc.) to the boring shall be measured and written on the field boring log for each boring or well installed, in addition to collecting GPS latitude/longitude/elevation data (pending equipment availability).
6) When sampling for VOCs or SVOCs, measure and record PID background readings immediately prior to start of drilling, and record breathing zone and background readings every 5 feet of depth or at points of any discoloration or odors.
7) Take photographs of the wellhead, drill rig, and samples for each borehole, and for any unusual circumstance and document in field notes.
8) All separate borings, including step-outs due to refusal or relocated borings for any reason, will be given a unique boring name. Each boring shall have its own field boring log prepared with appropriate notes as to the reason for stepping out, the geographical distances and directions between borings, and other information to provide complete documentation on the field log as well as in the field notes. Normally borings are named "SB-XX"; step-out borings can be numbered and lettered SB-XX**A**, SB-XX**B**, etc.

10) Divide your time between watching drilling activities, taking PID breathing space readings, collecting samples, logging soil, and recording everything. Avoid getting fixated on any one task at the expense of others. Remember that safety (i.e., breathing zone monitoring and drilling operations) is the top priority, followed by sample collection.

4.3. Procedures and Issues Specific to Direct Push Drilling

1) See EWI SOP ___ for details on how a direct push drilling machine is operated.

2) A DPT rig will push through cover materials, such as asphalt. Commonly, concrete is cored first, unless the rig has a concrete bit. Do not collect samples of these covering materials for analysis.

3) Drilling for samples may be performed using a macrocore (2-inch diameter) or using "dual tube" drilling with a smaller 1.25-inch diameter sampler. In both cases, the samplers will be 4 or 5 feet long and contain an acetate liner to collect the core. The smaller dual-tube system is used for non-cohesive geologic conditions where core may fall out through the larger sampler, or where the hole will not stay open to avoid sloughing. Note that less sample is collected using the dual tube system, so there could be insufficient sample volume if several analytes are required.

4) The sampler acetate tube should be measured to verify length, to provide an accurate reference for determining recovery.

5) Decontamination of drill samplers and rods (or augers, if used) should be conducted between samples and wells. The extent and techniques for decontamination can vary between simply brushing to remove gross surficial material, to standard soap and rinse scrubbing with or without a hotsy-type steam pressure sprayer. The appropriate methodology depends on project and regulatory requirements, and specified in the project sampling plan and/or quality assurance project plan.

6) If monitoring wells are to be installed using direct push technology, the maximum diameter will be 1-inch, pending State regulations for monitoring well construction (a variance may be required). The direct push rig (such as EWI's Geoprobe), may be equipped with augers, which enable a larger diameter (2-inch diameter) monitoring well.

7) Groundwater samples may be collected at selected footage intervals without installation of a monitoring well. DPT rigs may be equipped with a temporary well screen that can be inserted through the drill rods and "opened" at the desired depth. Tubing and a pumping or vacuum apparatus is used to extract groundwater so that a sample can be collected for analysis. Note that this technique yields a sample of undeveloped and unpurged groundwater.

8) DPT drilling may also be used for installing soil vapor points. This involves constructing "mini-monitoring wells" in the vadose (unsaturated) zone.

4.4. Procedures and Issues Specific to Auger Drilling

1) Auger rig rigs are larger and more powerful than DPT rigs, and capable of drilling larger diameter and deeper boreholes. Auger rigs can drill bores with an outside diameter from 4 to larger than 12 inches.
2) Augers can be solid stem or hollow stem. Hollow stem augers allow for soil sampling during drilling (split spoon, Shelby tube, or continuous sampler), and offer a "clean" way to construct a monitoring well. Inside diameter of hollow stem augers is about 2 to 4 inches smaller than the OD.
3) If monitoring wells are to be installed, be sure to plan large enough hollow stem augers to allow well construction inside the augers (per "Monitoring Well Construction" requirements for your State).
4) Auger drilling produces large quantities of soil cuttings, so containment, management, and disposal of soil cuttings must be planned prior to drilling. Saturated soil commonly produces a soupy cuttings mixture that can easily flow away from the wellhead area.
5) A good management technique is to set up plastic or plywood (with a hole cut in the center) around the wellhead for dry to moist cuttings placement if contaminants are known or could be anticipated, or to keep the work area clean if no contaminants are anticipated. Soil cuttings can be shoveled onto plastic and covered, or place in 55-gallon open-top drums.
6) If wet, soupy cuttings are anticipated, insure that a berm with plastic sufficient to contain liquid runoff around the wellhead is constructed.
7) Auger flights are decontaminated between wells, and samplers are decontaminated between samples, if sampling is conducted. If full scale decontamination is to be used, plan for a bermed area to contain spray water, and drums to contain decontamination fluids and mud that will be produced.
8) Auger drilling involves large equipment and heavy components, which are lifted manually and by drill hoist. Part of your job as a safety observer is to watch for dangerous situations, particularly when auger flights are being lifted and hoisted.

4.5. Completion Procedures and Hole Abandonment

1) At the completion of all drilling and sampling, the boring log must be checked to verify that it contains specific bore location, start and completion times, driller names (company and individual), type of drill equipment, sampling methodology (i.e. "2-in. diam., 4-ft. acetate liner), PID detections (including "0"), soil and groundwater sample IDs and intervals, and total depth (noting "refusal" if the case). Measure the location of the borehole with a direction and a distance from a known stationary object, such as to an existing well or corner of a building that has been surveyed in the past.
2) If not converted into monitoring well, boreholes need to be abandoned and plugged per State regulations. These steps explain the general procedure:

a. If possible, determine the actual depth of the borehole in case the hole collapsed, to calculate the volume of bentonite needed to plug the hole. Record the depth of the open borehole.

b. Pour bentonite pellets into the borehole up to the zone of saturation (note that some States require use of a tremie pipe in the saturated zone). If possible, tamp the pellets to insure compaction and no bridging in the bore.

c. Above the zone of saturation, add bentonite chips or pellets in one-foot lifts and hydrate with potable water.

d. Tamp the hydrated bentonite to compact the bentonite and to prevent bridging.

e. Repeat until the borehole is plugged to land surface. If within a building, the bentonite should extend to the base of concrete, and a concrete plug poured in the opening with the top smoothed.

f. Record the abandonment procedure on the boring's field lithologic log with types and quanitities of fill material used.

3) Mark each bore at ground surface with a labeled wooden stake driven into the ground, or by permanent marker/paint if indoors.

4) The back of the drilling rig and all equipment that went downhole needs to be decontaminated before the drill rig leaves the site. All equipment rinsate will be collected and subsequently disposed of at the site treatment facility.

5) Drill cuttings, decon water, and all trash (including acetate liners and cores) need to be properly stored and protected until disposed.

5. SAFETY

Acute or chronic exposure to chemically-contaminated soil could result in bodily injury. Routes of exposure include inhalation, ingestion, and dermal contact. Consult the appropriate chemical material safety data sheet (MSDS) before mobilization so that proper PPE and monitoring are planned and implemented.

Conduct an on-site safety meeting each day before the start of field work utilizing a Tailgate Safety Meeting form. Review safety hazards (e.g. high-traffic areas, exposure to chemicals, alertness to heavy equipment, PPE, health monitoring, and emergency procedures). Take appropriate action if personnel are injured on-site per EWI policy guidance.

When working with potentially hazardous substances, follow the United States Environmental Protection Agency (US EPA), Occupational Safety and Health Administration (OSHA), EWI Corporate Health and Safety Plan, and site-specific health and safety plan.

6. REFERENCES

- "Corporate Health and Safety Plan" Environmental Works, Incorporated.
- "HAZWOPER Training Manual: 40-Hour Hazardous Waste & Emergency Response Training." Safety Source, Inc

Environmental Works, Inc. SOP No. 2

Soil Logging & Sampling for Direct Push and Hollow-Stem Auger Rotary Drilling

ATTACHMENTS

Soil Boring Log

Air Monitoring Log

DIRECT AIR MONITORING LOG

Page ____ of ____

LOCATION:__________ DATE:__________ DRILLER:__________ MONITOR:__________
WEATHER:__________________ TEMP:__________ WIND:______________
MONITORING INST:____________________________ READINGS: PPM___ PPB___

TIME	DEPTH	BREATH ZONE	HOLE/ CASING	PIT/ TANK	BACK GROUND	BORING - COMMENTS

SOIL BORING LOG

Page _____ of _____

BORING NO._____

Ground Elev _____

Sampler _____

Driller _____

Location _____

Date _____ Start Time _____ Finish Time _____

Drill Equipm't _____ Sample Method _____

BACKGROUND		PID HEADSPACE MONITORING - PID Instrument:									
Time	ppm	Time	ppm	Time	ppm	Time	ppm	Time	ppm	Time	ppm

Abandonment Method _____

Depth BLS	Recovery (ft/ft)		Sample Depth	Sample Ident	PID (ppm)	Description of Material Drilled	Unified Classif

Skills Required:

1) 40-hour HAZWOPER training (if sampling on hazardous waste sites)
2) Understanding of, and ability to make decisions regarding, site-specific objectives
3) Training in soils characterization and sampling
4) Training and ability to use PID
5) Knowledge of corporate Safety requirements and health and safety plan

1.0 OBJECTIVE / APPLICABILITY

The Objective of this Standard Operating Procedure (SOP) is to provide the proper procedure for characterizing and logging soil during direct push and hollow-stem auger drilling.

This SOP serves as a reference tool to facilitate consistency among Environmental Works, Inc. (EWI) personnel. These operating procedures may be varied as required, depending upon site conditions, equipment limitations or limitations imposed by the project or client. In all instances, the ultimate procedures employed should be documented and associated with the final report.

2.0 SCOPE AND PERSONNEL APPLICATION

Soil characterization and logging is performed to provide qualitative information for evaluating site conditions, extent of contamination, and potential for contaminant transport. Soil sampling is done to provide quantitative analytical data for total amounts of chemicals of concern (COCs) in the soil at specified locations and depths. These analytical data are compared to federal and State regulatory levels (e.g., Missouri Risk-Based Corrective Action (MRBCA) target levels), to provide information for remediation decision-making.

Soil logging and sampling is normally performed by technical personnel (commonly EWI scientists and associate scientists). Any personnel performing these functions should be trained in proper identification and techniques. The person performing the function is responsible for ensuring that all equipment and materials necessary for logging and sampling are on-hand for the job. If there is any question regarding materials, the logger/sampler should confer with the project manager prior to mobilization to the work site.

3.0 EQUIPMENT

Equipment needed for soil logging and sampling may include but is not limited to:

a. A work plan outlining project soil sampling requirements
b. Field notebook or field documentation sheets
c. Plastic for logging table
d. Table for logging (portable table or plywood and sawhorses, 3'x5'
e. Small tape measure
f. Soil sampling spatula (or stainless steel spoon or butter knife)
g. Small spray bottle
h. Small plastic bucket for rinse/used gloves, etc.

i. Paper towels
j. Munsell color charts (in plastic baggies)
k. Soil characterization guide sheets
l. Appropriate tool for cutting acetate liners (with extra blades)
m. Sandwich size baggies (zip-lock type)
n. Quart size baggies (zip-lock type)
o. Nitrile or appropriate disposable gloves
p. Terra Core Soil Kits (includes 1 methanol 40ml vial, 2 sodium phosphate tribasic 40ml vials, 2 unpreserved 40ml vials, 1 unpreserved amber jar, and 1 disposable Terracore^{RM} sampler) if required for sampling.
q. PID and calibration gas for VOC sites (including diesel and gasoline sites)
r. Camera (digital best)
s. Collection jars appropriate for analytes (provided by analytical laboratory)
t. Soil trip blank(s) (provided by analytical laboratory)
u. Temperature blank(s) (provided by analytical laboratory)
v. Sample labels
w. Chain of Custody (COC)
x. Cooler to store samples
y. Ice
z. Packing tape
aa. Duct tape
bb. Fine-tipped Sharpie
cc. UPS/Fed-Ex Shipping label(s)
dd. Custody Seal(s)
ee. Trash bags
ff. PPE appropriate for the site and COCs
gg. Soil boring logs, Air Monitoring Logs
hh. Site Safety and Health Plan, Tailgate Safety Form

4.0 PROCEDURES

4.1 General Procedures

1) Setup and organize logging area well before drilling starts. Have PID on and calibrated. Organize materials to be readily available within reach.

2) Know the type of soil sampling to be performed (Geoprobe 2" liners, 1" liners, 2-foot split spoons 2"-3" diameter, Shelby tube, 5-foot continuous samplers 3"-4" diameter, or grab samples from auger cuttings) and plan ahead how logging, sampling, PID readings will best be done. Procedures will vary whether operating alone or with another person.

3) The general procedure steps for logging and sampling are:
   - Note general geology, obvious areas of impact, recovery
   - Slit the core lengthwise, measure and record PID readings
   - Note water saturation level
   - Select horizons to sample and collect samples

- Collect small representative samples in baggies (labeled with depth)
- Perform detailed lithologic characterization of core
- Measure PID readings inside baggies, use for Munsell color determination
- Measure and record recovery (inches of core / inches sampler length)
- Take pictures of core

4) Stop driller if you get behind in logging and sampling a run. Don't just let sample tubes collect waiting for processing. Complete and accurate data are needed.
5) Divide your time between watching drilling activities, taking PID breathing space readings, collecting samples, logging soil, and recording everything. Avoid getting fixated on any one task at the expense of others.
6) Use Daily Field Logs, Boring Logs, and Air Monitoring Logs to record all pertinent information and activities as the job progresses. You do not have to record repetitive information. Example boring logs and air monitoring logs are attached.

4.2 Lithologic Characterization

Examine each different geologic material in the core, noting and recording the following properties for each type in the order presented. Different guide sheets in the attachments provide detailed explanations how to characterize each property, as well as an abbreviated list for use in the field.

- **MAIN TYPE OF MATERIAL** (fill, sand, clay, etc.)
  and **SUPPLEMENTAL** (sandy, silty, clayey, gravelly)
  (Usually written like Silty CLAY, or Clayey SAND, or Gravelly CLAY, or CLAY and GRAVEL (if 50/50). If mixture, note percentage of lesser (e.g., CLAY w/ 20% GRAVEL)
- **GRAIN SIZE** (if not clay) – fine, medium, coarse.
  For gravel also give size range in inches (e.g., 1/8" to pea size) and roundness (e.g., angular, subrounded, rounded)
- **SORTING AND GRADING** (if not clay):
  Poorly sorted (all different sizes) to well sorted (all same size)
  Poorly graded (different sizes all mixed up in position) to
  well graded (different sizes occur in sequential layers – coarse to fine)
- **COHESIVENESS**
  Very soft, soft, firm, stiff, v. stiff, hard *if cohesive*
  Very loose, loose, med dense, dense, extreme dense *if non-cohesive*
  Plasticity for clays (non-plastic, low, medium, or high plasticity)
- **COLOR**
  Note overall color. If two distinct colors, specify both. Note supplemental, like "mottled" or "brown laminations, etc". Specifically note areas of impact or

discoloration. Use Munsell color charts, comparing soil to color spots and recording the Munsell color code. Add text color later from Munsell code sheet. OK to note "multicolored" without Munsell codes if many colors. Recommend keeping Munsell charts in large plastic baggies to protect color spots. See example Munsell color spots and code sheets in the attachments.

- **SATURATION**

  Note & record dry, damp, slightly moist, moist, very moist, saturated (or wet)

  Saturation can be difficult to determine in clay. Clay may be saturated and not appear "wet" – attempt to squeeze a small amount of sample to see if water is released.

- **ODOR**

  State either "no odor" or any noted odor, e.g., "petroleum-like". Limit use of specifics, e.g., diesel or gasoline, and always use "-like".

- **ANY INDICATORS OF CONTAMINATION**

  Discoloration, free product, odors

Abbreviations on field sheets are OK if logical. Include a key if not. The following are examples of log entries:

CLAY, 20% pea gravel, subround, stiff, low plastic, olive brn (2.5Y 4/3) w/ orange mottling, moist, no odor or visual impact

Clayey SAND, fin-gr, well sort, soft, pale brn (10YR 6/3) w/ dk gray irreg patches to ½", saturated, petroleum-like odor, impact in dk discolored areas

5.5'-6': GRAVEL lens, poor sorted 1/8" – ½", well graded (coarse down), med dense, lt gray (5YR 7/1) and dk gray (5YR 4/1), v. moist, no odor or visual impact

While all of the above properties are needed to fully characterize geologic materials, the following are the key properties that must be recorded:

- Type of material including supplemental types
- Grain size if not clay
- Color by Munsell charts
- Saturation level
- Indications of impact

4.3 PID Measuring and Sampling Cores (liners, split spoons, Shelby tubes, continuous samplers)

1) Spoons/samplers/Shelby tubes should not be opened, or acetate liners cut open, until you are ready to begin logging.

2) As soon as the core is exposed, use a sampling spatula or other flat, dull-blade knife to slit the core lengthwise and measure PID readings. Carefully insert the

PID tip into the space made while "twisting" the spatula/knife - care must be taken to avoid plugging the PID tip. Measure every 6" and at areas of suspected impact. With a team of two persons, one person should measure starting depth and reading, while the 2nd person records the values – both the depth and reading should be noted on the boring log. If working alone, measure and record no more than 3 readings at a time to maintain accuracy.

3) Once core PID readings are recorded, and general lithology, saturation level, and potential areas of impact have been identified, samples must be collected.

4) Collect samples using a spatula/flat knife decontaminated between sampled horizons to fill sample jars. Collect samples as quickly as possible, remembering that samples for VOC analysis must be packed as tightly as possible in the sample container without over-pushing, squeezing samples. Label the sample container, insert in a baggie, and place in a cooler with ice. If time-constrained, write sample ID, depths, and time on lid and add labels later. If using a 5035 kit, see the 5035 SOP for proper procedures.

5) Samples should be given logical identifications to include the collection depth, e.g.: SB-4: 4.5-5 for a sample collected from SB-4 between 4.5'-5'.

6) Clearly depict sample horizons and ID on the boring log, noting depths.

7) After samples are collected, take depth baggies and measure headspace with PID after at least 5 minutes, and record. Beware of saturated samples, which can produce a temporary peak in PID readings. These baggies are also a good way to evaluate Munsell color of the interval when time allows

4.4 Logging and Sampling from Auger Cuttings

If hollow stem drilling is conducted without use of split spoons, Shelby tubes, or continuous samplers, grab soil samples for characterization and chemical analysis can still be collected from auger cuttings returned to the surface from the augers. The following are considerations and procedures related to soil sampling in these conditions.

1) There are limitations and potentially adverse effects from sampling auger cuttings that should be considered in collecting samples:

- Collecting samples while actively augering involves your movement close to the drill rig and moving parts, so this action requires keen attention to detail and situational awareness.
- The actual depth of the sample is uncertain, because there is a time delay in the sample reaching the surface while the augers continue downward.
- Detailed PID depth profiles cannot be discerned due to mixing of thinner horizons of soil by the augers; however, auger movement can release more volatiles and yield more readily detected elevated PID readings.
- If the chemicals of concern are highly volatile, it is likely that movement of the augers and the heat of friction will reduce the volatile content of samples, so results must be considered as minimal concentrations.

- Finer details of lithology (thin horizons, sorting, grading, coloration, contamination details) are not possible when logging auger cuttings.
- Moisture content can be difficult to accurately determine because of heat drying soils. However, saturated soil commonly produces a soupy return, making identification of true saturation easy to determine.

2) If samples are collected from auger cuttings, they must be collected using a sampling implement (not gloved hands) and placed rapidly into containers to minimize loss of volatiles. The freshest, most recently arrived sample should be selected. "Old" soil that has been stuck on augers should not be used.

3) Samples for lithologic description and color should be grabbed at regular intervals and set aside for logging and marked somehow with depth. Samples for PID headspace should be placed in baggies labeled with depth.

4) Actual depth of the augers immediately at the time of fresh sample collection should be recorded. Many variables (soil type, density, moisture content, power of the rig, etc.) result in unpredictable lag time of cutting reaching the surface.

5) Appropriate naming for grab samples from augers would be: SB-4: 6G for a grab sample collected at 6 ft depth. Depth cannot be determined accurately enough to provide a range over which a single grab sample was collected.

6) Use of auger cuttings for samples, technique of collection, and definition of depth assignment should be noted on the boring field log.

5.0 FIELD QA/QC SAMPLING PROCEDURES

Quality assurance/quality control sampling should be performed to assure quality of field analytical data. The following QA/QC sampling should be done as appropriate for regulatory or client requirements, or project constraints:

- Select 10% of total samples for duplicate sampling and analysis, with a minimum of one sample collected per event. Duplicate samples should be assigned a fictitious name, but one that can be recognized (e.g., add a "2" after the primary sample name: SB-32 as a duplicate of SB-3).
- Collect and analyze one field blank sample when collecting water samples.
- Utilize Trip Blanks sent from the laboratory when VOC sampling.
- Collect one equipment rinsate blank from geoprobe macrocores, split spoons, continuous samplers, or sampling utensils after being decontaminated.

Field duplicate samples are analyzed to check for sampling and analytical reproducibility.

Trip blanks will be used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage. One laboratory-supplied trip blank will be forwarded with each cooler containing samples and analyzed for VOCs.

Field blanks will be collected to assess possible impact from external contaminant sources in the area of sampling. Blanks will be collected by filling sample bottles with dionized/distilled water at the logging/sampling table and submitted for analysis of VOCs.

Equipment rinsate blanks will be taken to assess the effectiveness of decontamination and any potential impact on cross-contamination between samples. Blanks will be prepared by routing deionized/distilled water through decontaminated sampling equipment and before field sample collection. Rinsate blanks can be submitted for VOC and/or other analytes, depending on what the analytes of concern are at the job site.

6.0 SAFETY

Acute or chronic exposure to chemically-contaminated soil could result in bodily injury. Routes of exposure include inhalation, ingestion, and dermal contact. Consult the appropriate chemical material safety data sheet (MSDS) before mobilization so that proper PPE and monitoring are planned and implemented.

Conduct an on-site safety meeting each day before the start of field work utilizing a Tailgate Safety Meeting form. Review safety hazards (e.g. high-traffic areas, exposure to chemicals, alertness to heavy equipment, PPE, health monitoring, and emergency procedures). Take appropriate action if personnel are injured on-site per EWI policy guidance.

When working with potentially hazardous substances, follow the United States Environmental Protection Agency (US EPA), Occupational Safety and Health Administration (OSHA), EWI Corporate Health and Safety Plan, and site-specific health and safety plan.

7.0 REFERENCES

- "Corporate Health and Safety Plan" Environmental Works, Incorporated.
- "HAZWOPER Training Manual: 40-Hour Hazardous Waste & Emergency Response Training." Safety Source, Inc

Environmental Works, Inc. SOP No. 3

Soil Logging & Sampling for Direct Push and Hollow-Stem Auger Rotary Drilling

ATTACHMENTS

Soil Boring Log

Air Monitoring Log

GEOLOGIC LOGGING – INFO AND ORDER TO RECORD

Visual Percent Estimation Charts (un-named)

Field Guide for Soil and Stratigraphic Analysis v.2

Unified Soil Classification System

Soil Classification System (Modified U.S.C.)
Conventional Soil Descriptions

Instructional Diagram for Determining Soil Texture by Feel

Munsell color chart (example pages)

Munsell Soil Color Names (example pages)

Environmental Works, Inc.

Soil Boring Log

Date/Time: _____

Sampler: _____

Driller: _____

Boring ID: _____

Site Name: _____

Drill Equipm't and Method: _____

Location: _____

Depth	Recovery	Sample Depth / ID	PID BZ	Sample PID	Description of Material	USCS

GEOLOGICAL LOGGING – INFO AND ORDER TO RECORD

MAIN TYPE OF MATERIAL (sand, clay, clay, etc.)
and **SUPPLEMENTAL** (sandy, silty, clayey with %)

GRAIN SIZE sand – fine, medium, coarse - and supplemental
gravel –size in inches, roundness, % if supplemental

SORTING AND GRADING (for sands and gravels)
Sorting (size): Poor to well
Grading (size mix): Poor to well

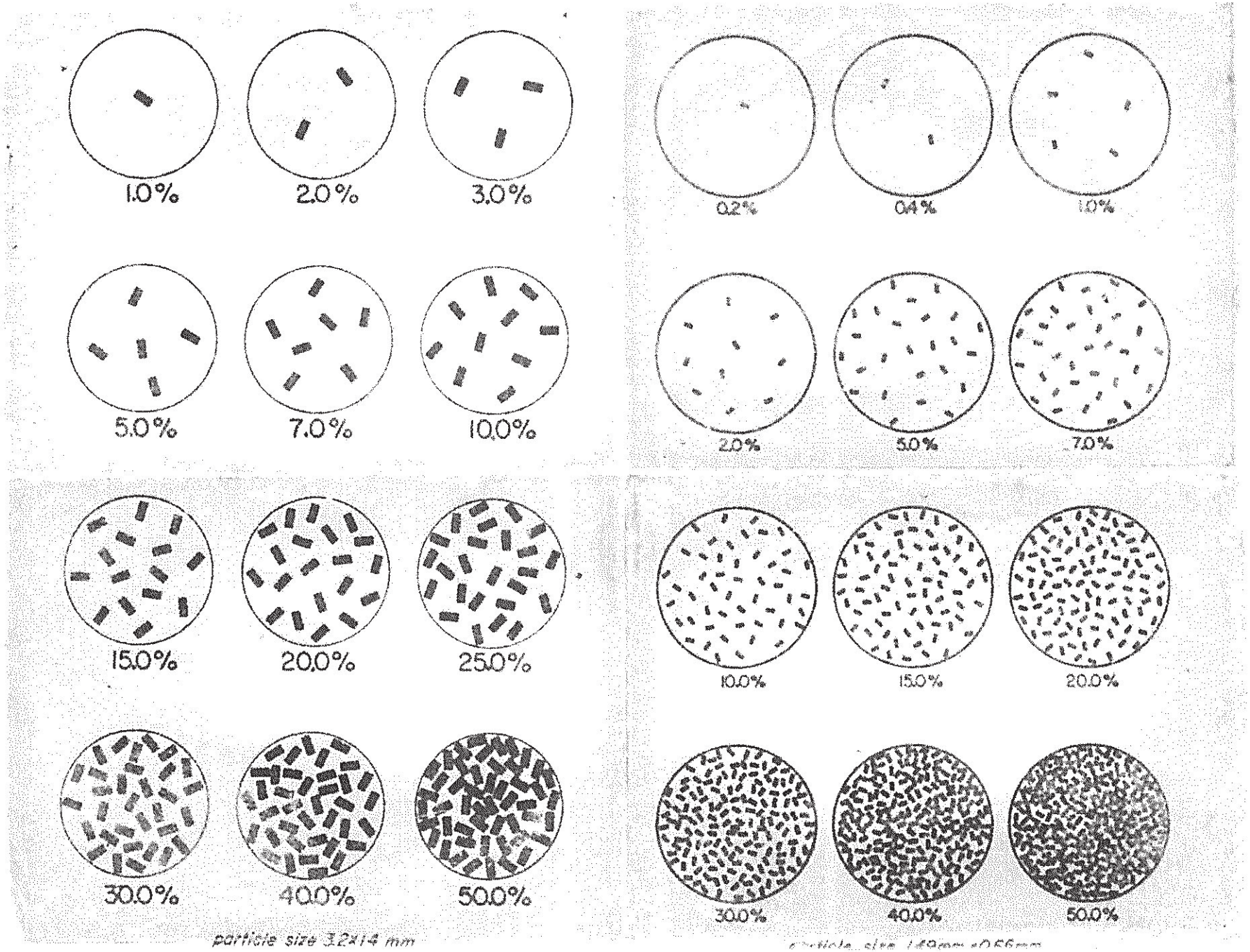
COHESIVENESS
Very soft….soft…firm…stiff… v. stiff… hard *(cohesive)*
Plasticity for clays
Very loose…loose…med dense…dense…extreme dense *(non-cohesive)*

COLOR Name (Munsell number)

SATURATION
Dry…damp…slightly moist…moist…very moist…saturated

ODOR

ANY INDICATORS OF CONTAMINATION


1.0%
2.0%
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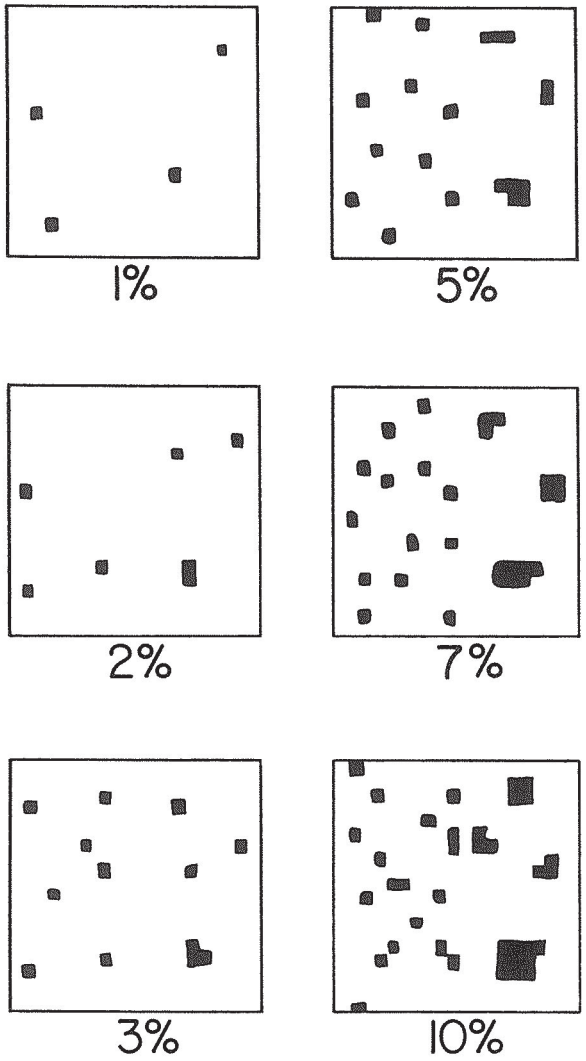
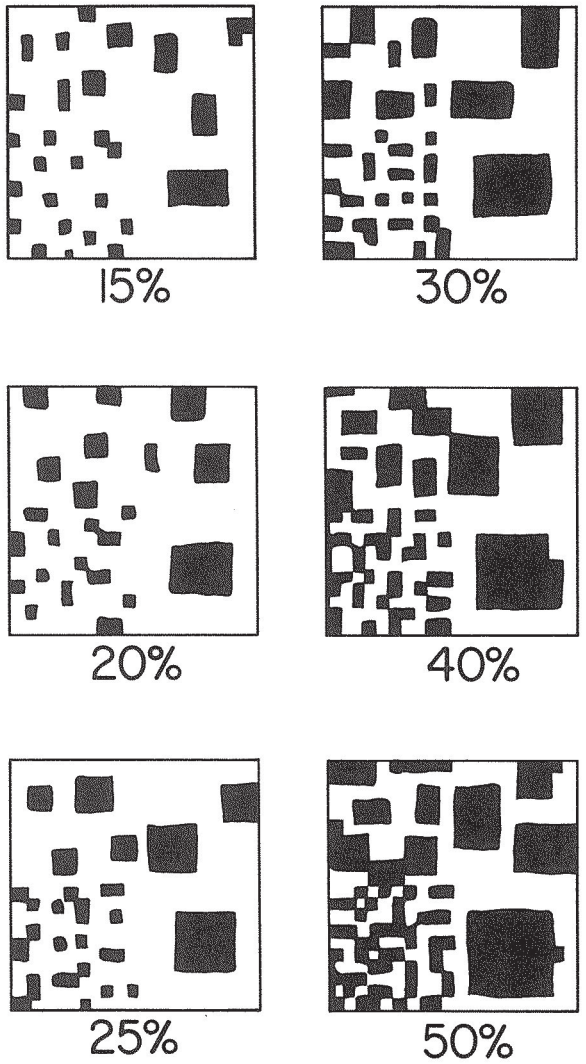
2.0%
5.0%
7.0%
10.0%
15.0%
20.0%
30.0%
40.0%
50.0%
particle size 3.2x1.4 mm

CHARTS FOR ESTIMATING PROPORTIONS OF MOTTLES AND COARSE FRAGMENTS





Each fourth of any one square has the same amount of black

UNIFIED SOIL CLASSIFICATION SYSTEM

FOR COMMON INORGANIC AND ORGANIC SEDIMENTS

Modified from ASTM

STEP 1:
IS SEDIMENT COARSE GRAINED OR FINE GRAINED?

COARSE-GRAINED DEPOSITS

(>50% coarse-grained, <50% fine sediments)

STEP 2: DETERMINE SAND VS. GRAVEL RATIO

INCREASING GRAIN SIZE

0.075 MM		4.75 MM		75.0 MM
SAND			GRAVEL	

0.075 MM	0.425 MM	2.0 MM	4.75 MM	19.0 MM	75.0 MM
FINE	MEDIUM	COARSE	FINE	COARSE	

STEP 3:
*CONTINUE WITH "SAND" OR "GRAVEL" AND FOLLOW FLOW CHART TO ASSIGN A **GROUP SYMBOL** AND A **GROUP NAME***

			GROUP SYMBOL		GROUP NAME
Gravel (gravel > sand)	<5% fines	Well graded (non-uniform)	GW	<15% sand	WELL GRADED GRAVEL
				>15% sand	WELL GRADED GRAVEL WITH SAND
		Poorly graded (uniform)	GP	<15% sand	POORLY GRADED GRAVEL
				>15% sand	POORLY GRADED GRAVEL WITH SAND
	10% fines	Well graded (non-uniform)	GW-GM	<15% sand	WELL GRADED GRAVEL WITH SILT
				>15% sand	WELL GRADED GRAVEL WITH SILT AND SAND
			GW-GC	<15% sand	WELL GRADED GRAVEL WITH CLAY
				>15% sand	WELL GRADED GRAVEL WITH CLAY AND SAND
		Poorly graded (uniform)	GP-GM	<15% sand	POORLY GRADED GRAVEL WITH SILT
				>15% sand	POORLY GRADED GRAVEL WITH SILT AND SAND
			GP-GC	<15% sand	POORLY GRADED GRAVEL WITH CLAY
				>15% sand	POORLY GRADED GRAVEL WITH CLAY AND SAND
	>15% fines		GM	<15% sand	SILTY GRAVEL
				>15% sand	SILTY GRAVEL WITH SAND
			GC	<15% sand	CLAYEY GRAVEL
				>15% sand	CLAYEY GRAVEL WITH SAND
Sand (sand > gravel)	<5% fines	Well graded (non-uniform)	SW	<15% gravel	WELL GRADED SAND
				>15% gravel	WELL GRADED SAND WITH GRAVEL
		Poorly graded (uniform)	SP	<15% gravel	POORLY GRADED SAND
				>15% gravel	POORLY GRADED SAND WITH GRAVEL
	10% fines	Well graded (non-uniform)	SW-SM	<15% gravel	WELL GRADED SAND WITH SILT
				>15% gravel	WELL GRADED SAND WITH SILT AND GRAVEL
			SW-SC	<15% gravel	WELL GRADED SAND WITH CLAY
				>15% gravel	WELL GRADED SAND WITH CLAY AND GRAVEL
		Poorly graded (uniform)	SP-SM	<15% gravel	POORLY GRADED SAND WITH SILT
				>15% gravel	POORLY GRADED SAND WITH SILT AND GRAVEL
			SP-SC	<15% gravel	POORLY GRADED SAND WITH CLAY
				>15% gravel	POORLY GRADED SAND WITH CLAY AND GRAVEL
	>15% fines		SM	<15% gravel	SILTY SAND
				>15% gravel	SILTY SAND WITH GRAVEL
			SC	<15% gravel	CLAYEY SAND
				>15% gravel	CLAYEY SAND WITH GRAVEL

STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL

INCREASING PLASTICITY

NON PLASTIC	LOW PLASTICITY	MEDIUM PLASTICITY	HIGH PLASTICITY
ML	CL		CH

STEP 3:
*CONTINUE WITH **GROUP SYMBOL** AND FOLLOW FLOW CHART TO ASSIGN A **GROUP NAME***

FINE-GRAINED DEPOSITS

(>50% fines, <50% coarse-grained sediments)

STEP 4:
DOES ORGANIC CONTENT INFLUENCE SOIL PROPERTIES?

YES / *NO*

				GROUP NAME
ML	less than 30% Coarse Grained Sediments	< 15% Coarse-Grained Sediment		SILT
		15-25% Coarse-Grained Sediment	% sand > % gravel	SILT WITH SAND
			% sand < % gravel	SILT WITH GRAVEL
	more than 30% Coarse Grained Sediments	% sand > % of gravel	<15% gravel	SANDY SILT
			>15% gravel	SANDY SILT WITH GRAVEL
		% sand < % gravel	<15% sand	GRAVELLY SILT
			>15% sand	GRAVELLY SILT WITH SAND
CL	less than 30% Coarse Grained Sediments	< 15% Coarse-Grained Sediment		LEAN CLAY
		15-25% Coarse-Grained Sediment	% sand > % gravel	LEAN CLAY WITH SAND
			% sand < % gravel	LEAN CLAY WITH GRAVEL
	more than 30% Coarse Grained Sediments	% sand > % of gravel	<15% gravel	SANDY LEAN CLAY
			>15% gravel	SANDY LEAN CLAY WITH GRAVEL
		% sand < % gravel	<15% sand	GRAVELLY LEAN CLAY
			>15% sand	GRAVELLY LEAN CLAY WITH SAND
CH	less than 30% Coarse Grained Sediments	< 15% Coarse-Grained Sediment		FAT CLAY
		15-25% Coarse-Grained Sediment	% sand > % gravel	FAT CLAY WITH SAND
			% sand < % gravel	FAT CLAY WITH GRAVEL
	more than 30% Coarse Grained Sediments	% sand > % of gravel	<15% gravel	SANDY FAT CLAY
			>15% gravel	SANDY FAT CLAY WITH GRAVEL
		% sand < % gravel	<15% sand	GRAVELLY FAT CLAY
			>15% sand	GRAVELLY FAT CLAY WITH SAND
OL / OH	less than 30% Coarse Grained Sediments	< 15% Coarse-Grained Sediment		ORGANIC SOIL
		15-25% Coarse-Grained Sediment	% sand ≥ % gravel	ORGANIC SOIL WITH SAND
			% sand < % gravel	ORGANIC SOIL WITH GRAVEL
	more than 30% Coarse Grained Sediments	% sand ≥ % of gravel	<15% gravel	SANDY ORGANIC SOIL
			≥15% gravel	SANDY ORGANIC SOIL WITH GRAVEL
		% sand < % gravel	<15% sand	GRAVELLY ORGANIC SOIL
			≥15% sand	GRAVELLY ORGANIC SOIL WITH SAND

ASTM charts reprinted with permission

FIELD GUIDE FOR SOIL AND STRATIGRAPHIC ANALYSIS v.2

midwest GEOSCIENCES group
www.midwestgeo.com

START HERE

DENSITY OR CONSISTENCY

COARSE GRAINED DEPOSITS	N-VALUE	
	0-4	► VERY LOOSE
	5-10	► LOOSE
	11-29	► MEDIUM DENSE
	30-49	► DENSE
	>50	► VERY DENSE

FINE GRAINED DEPOSITS	N-VALUE	q_u (tsf)	
	0-2	<0.25	► VERY SOFT
	3-4	0.25-0.50	► SOFT
	5-8	0.50-1.0	► MEDIUM
	9-15	1.0-2.0	► STIFF
	16-30	2.0-4.0	► VERY STIFF
	>30	>4.0	► HARD

COLOR
Use Standard Munsell Color Notation

IS THE COLOR A MATRIX COLOR?
- YES → **MATRIX COLOR** — List in sequence, dominant first
- NO → IS THE COLOR FROM A COATING OR CONCENTRATION?
  - YES → **COATING or CONCENTRATION** — Note frequency, color, and size
  - NO → **MOTTLE** — Note contrast, color, and size

CLASSIFICATION
Unified Soil Classification System - adopted ASTM D2488

COARSE-GRAINED DEPOSITS
>50% coarse-grained sediments, <50%fines

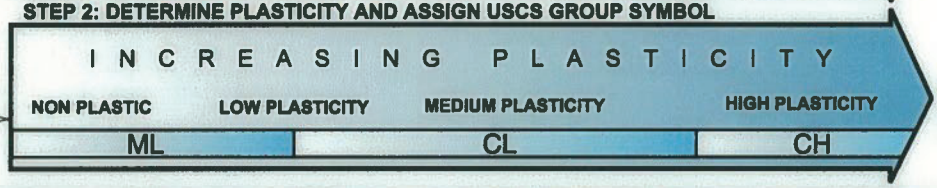
STEP 1: IS SEDIMENT COARSE GRAINED OR FINE GRAINED?

STEP 2: DETERMINE SAND VS. GRAVEL RATIO

STEP 3: *CONTINUE WITH SAND OR GRAVEL ON FLOW CHART (REVERSE)*

FINE-GRAINED DEPOSITS
(organic and inorganic)
>50% fines, <50% coarse-grained sediments

STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL



STEP 3: *CONTINUE WITH GROUP SYMBOL ON FLOW CHART (REVERSE)*

MOISTURE

MOISTURE ABSENT	► DRY	FOR NON-PLASTIC FINES	WATER RISES TO SURFACE SLOWLY ► SLOW DILATENCY
DAMP	► MOIST		WATER RISES TO SURFACE QUICKLY ► RAPID DILATENCY
VISIBLE WATER	► WET		

PLASTICITY
(Use with CLASSIFICATION)

WILL NOT SUPPORT 6mm DIAMETER ROLL IF HELD ON END	► NON-PLASTIC
6mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 4mm DIA. ROLL DOES NOT	► LOW PLASTICITY
4mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 2mm DIA. ROLL DOES NOT	► MEDIUM PLASTICITY
2mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF	► HIGH PLASTICITY

COHESIVENESS

6mm DIAMETER ROLL CANNOT BE FORMED	► NONCOHESIVE
6mm DIAMETER ROLL CAN BE FORMED	► COHESIVE

SEDIMENTARY STRUCTURE

UNIFORM BEDS >30cm	► MASSIVE
BEDS 3cm to 30cm	► THICKLY BEDDED
BEDS 0.5cm to 3cm	► BEDDED
BEDS <0.5cm	► THINLY BEDDED
	► LAMINATED

SECONDARY SOIL STRUCTURE (IN SOLUM ONLY)

Spheroidal peds or granules usually packed loosely	► GRANULAR
Irregular, roughly cubelike peds with planar faces (angular or subangular)	► BLOCKY
Flat and horizontal peds	► PLATY
Vertical, pillarlike peds with flat tops	► PRISMATIC
Vertical, pillarlike peds with curved tops (which are commonly "bleached")	► COLUMNAR

WEATHERING ZONE ABBREVIATION

MODIFIER SYMBOL (if present)		1st SYMBOL		2nd SYMBOL		LAST SYMBOL (if present)	
MOTTLED	► M	OXIDIZED	► O	LEACHED	► L	SECONDARY CARBONATE	► 2
JOINTED	► J	REDUCED	► R	UNLEACHED	► U		
		UNOXIDIZED	► U				

EXAMPLE

solum	
OJL	MRJU
MOJL	RJU
MOJL2	RU
MOJU	UU

SECONDARY GRAIN SIZE INFORMATION

< 5%	► TRACE
6% to 15%	► FEW
16% to 30%	► LITTLE
31% to 49%	► SOME

► UNIFORM (poorly graded)
► NON-UNIFORM (well graded)

► FINE SAND
► MEDIUM-GRAINED SAND
► COARSE-GRAINED SAND
► FINE GRAVEL
► COARSE GRAVEL

FOR GLACIAL DIAMICTONS ► CLAST FRACTION ► CLAST LITHOLOGY

DEPOSITIONAL ENVIRONMENT

VARIOUS DEPOSITIONAL ENVIRONMENTS (Interpretation)
- ► EOLIAN (LOESS)
- ► FLUVIAL
- ► ALLUVIAL
- ► LACUSTRINE
- ► COASTAL
- ► RESEDIMENTED

GLACIAL DEPOSITIONAL PROCESSES
- ► SUBGLACIAL
- ► GLACIOFLUVIAL
- ► GLACIOLACUSTRINE
- ► RESEDIMENTED

GENERALIZED RESEDIMENTATION PROCESSES
- ► MASS SLUMP
- ► SEDIMENT FLOW
- ► COLLUVIUM

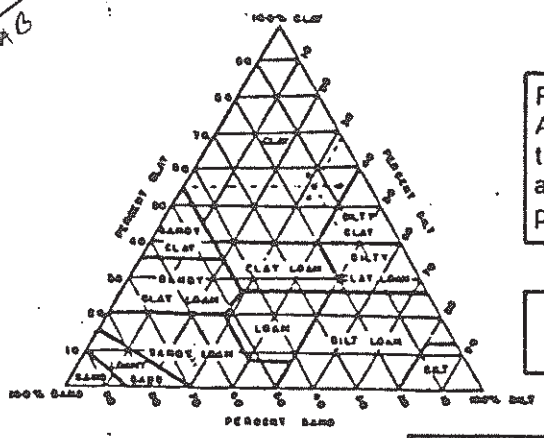
STRATIGRAPHIC NAME

USE FORMAL STATE GEOLOGICAL SURVEY NOMENCLATURE WHEN POSSIBLE;
IF NOT POSSIBLE, ASSIGN SITE-SPECIFIC UNIT NAME ACCORDING TO DEPOSITIONAL ENVIRONMENT / FACIES ASSEMBLAGE

STRATIGRAPHIC CONTACT

010108

< 10 cm	► SHARP (or ABRUPT for pedogenic alternation)
> 10 cm (Note transition interval)	► GRADATIONAL (or TRANSITIONAL for weathering zone change)



Start

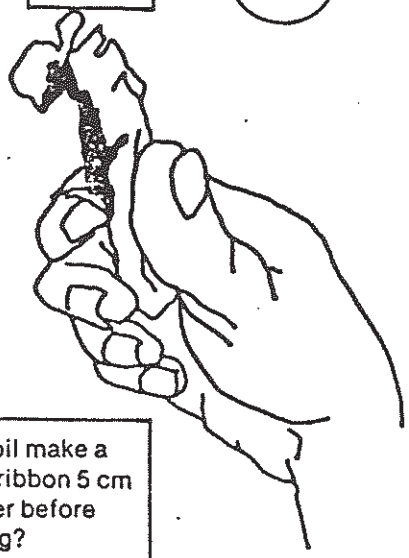
Place approximately 25 g soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.

Add dry soil to soak up water

Does soil remain in a ball when squeezed? NO → Is soil too dry? YES / NO → Is soil too wet? YES / NO → SAND

YES

Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.



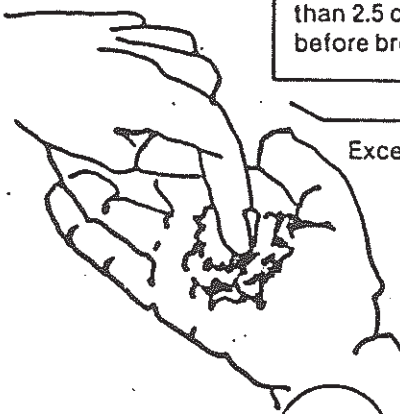
Does soil form a ribbon? NO → LOAMY SAND

YES

Does soil make a weak ribbon less than 2.5 cm long before breaking? NO → Does soil make a medium ribbon 2.5–5 cm long before breaking? NO → Does soil make a strong ribbon 5 cm or longer before breaking?

YES

Excessively wet a small pinch of soil in palm and rub with forefinger



Does soil feel very gritty?	Does soil feel very smooth?	Neither grittiness nor smoothness predominates
YES → SANDY LOAM	YES → SILT LOAM	YES → LOAM
NO	NO	
YES → SANDY CLAY LOAM	YES → SILTY CLAY LOAM	YES → CLAY LOAM
NO	NO	
YES → SANDY CLAY	YES → SILTY CLAY	YES → CLAY
NO	NO	

Fig. 1. Instructional diagram for determining soil texture by feel.

Skills Required:

1) Site-specific health & safety training.
2) Corporate procedures on field documentation methods and soil boring logging
3) Drilling operations.
4) Site-specific data quality objectives and corporate quality assurance.

1.0 OBJECTIVE / APPLICABILITY

The Objective of this Standard Operating Procedure (SOP) is to provide procedures for EWI personnel to employ Terra Core® Method 5035 when collecting soil samples of soil for volatiles analysis.

In June 1997, the United States Environmental Protection Agency (EPA) adopted Method 5035 for the sampling and analysis of total amounts of volatile organic compounds (VOCs) in solids. This method does not apply to samples collected for leachate analysis such as those for the Toxicity Characteristic Leachate Procedure (TCLP).

Method 5035 was adopted because of studies showing that sampling according to the previous methods resulted in significant losses of selected VOCs. Method 5035 incorporates chemical preservatives and sample storage techniques to limit volatilization and biodegradation of VOCs.

This is a standard operating procedure, which may be varied as required dependent of site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedure employed should be documented and associated with the final report.

2.0 SCOPE

This SOP describes the process of collecting soil samples using the 5035 method. The scope of this SOP is limited to retrieval of the soil to be sampled (using a push probe, excavator or hand auger) through packaging the sample for shipment to a laboratory.

3.0 EQUIPMENT

Equipment needed for Terra Core® Method 5035 Soil Sampling include:

a. A work plan outlining soil sampling requirements for the project
b. Terra Core Soil Kits (typical kit includes 1 methanol 40-ml vial, 2 sodium phosphate tribasic 40-ml vials, 2 unpreserved 40-ml vials, 1 unpreserved 2-oz or 4-oz jar, and 1 disposable Terra Core sampler).
c. Chain of Custody
d. Two gallon plastic bags
e. Cooler to store samples
f. Ice
g. Packing tape
h. Duct tape
i. Fine-tipped Sharpie

j. UPS/Fed-Ex Shipping label(s)
k. Custody Seal(s)
l. Disposable sampling gloves
m. Paper Towels
n. Trash bags

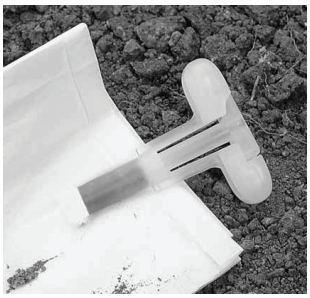
4.0 PROCEDURES

4.1 Pre-Operation

(1) Gather all equipment needed and review the work plan/work request.
(2) Review contents of the laboratory cooler. Ensure that all Terra Core® kits, trip blanks, temperature blanks, chain of custody, sample labels and shipping labels are present
(3) Conduct an on-site safety meeting each day before the start of the project. Review safety hazards (e.g. high-traffic areas, exposure to chemicals, alertness to heavy equipment). Have all personnel sign the Tailgate Safety Meeting Form (see Appendix A) each day before the start of the project.
(4) Have the driller/excavator collect the soil to be sampled. Assess qualitative characteristics of soil (i.e. soil type, odor, presence of chert, color, etc) and record observations on soil boring log. Collect soil sample for PID reading according to SOP #4.

4.2 Operation

(5) Identify the zone in the soil core that is to be sampled. In a typical soil core, approximately six inches of soil will need to be present to collect a sample using this method. Avoid soil zones that contain excessive amounts of gravel or chert fragments.
(6) Insert the Terra Core sampler into the soil to the base of the plunger as shown in the first photo below. **Always wear disposable gloves when handling the vials, the Terra Core and the sample**.
(7) Wipe soil or debris from the outside of the Terra Core® sampler. The soil plug should be flush with the mouth of the sampler as shown in the second photo.
(8) Rotate the plunger that was seated in the handle top 90° until it is aligned with the slots in the body. Place the mouth of the sampler into the 40ml VOA vial containing the appropriate preservative and extrude the sample by pushing the plunger down (see third photo). Quickly place the lid back on the 40ml VOA vial.


(9) Repeat Steps #5 - #8 until all 40-mL vials are filled with approximately five grams of soil. For each sample, most laboratories provide five 40-mL vials: two preserved with sodium phosphate tribasic (TSP), two unpreserved and one preserved with methanol.

(10) Fill the 2 or 4 oz glass jar with soil from the same zone as where the sample was collected from. You do not need to use the Terra Core to fill this jar.

(11) Dispose of the Terra Core sampler.

(12) Write sample ID, date, time, and sampler name on each pre-labeled vial and glass jar. **Note: The sample kits are pre-labeled and pre-weighed. Do NOT attach a new label to any of the jars as this will alter the net weight of the jar or vial.**

(13) Place soil sample kit in a two gallon plastic bag, seal the bag, and then place the bag in the cooler on ice.

(14) Repeat steps 5-13 until all soil samples are collected.

(15) Make sure coolers are packed with plenty of ice to keep the samples at 4°C. Include one trip blank and one temperature blank per cooler or as required by the site-specific work plan.

(16) Keep the copy of chain of custody and place the completed original chain of custody in a plastic bag. Tape the plastic bag with the chain of custody securely to the inside of the cooler lid.

(17) Tape up cooler(s) with packing tape. Make sure to tape over drain valves on the coolers, if applicable.

(18) Sign and date the custody seal(s).

(19) Place the custody seal over the cooler opening and secure with a piece of packing tape.

(20) Complete the Shipping Label. Keep shipper's copy and attach original to the cooler(s).

(21) Ship coolers for next day delivery. NOTE: For the laboratory to analyze the samples using the unpreserved sample containers, the samples must be received by the laboratory no later than 48 hours after sample collection.

5.0 REFERENCES

(1) SW-846 EPA publication "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm

(2) En Novative Technologies, Inc. *Recommended Use Of The Terra Core®*